THESIS

The Conductivity of Heat in Building Papers.

FOR THE DEGREE OF

B. S.

SCHOOL OF ARCHITECTURE.

JAMES M. WHITE.

1890.

The Conductivity of Heat in Building Papers.

In making the following experiments, heat from a constant source was permitted to pass through the material being tested and was then communicated to a calorimeter of water. The figures given in the following tables are the time in minutes which was required to raise the water 15° C.

The source of heat was a pot of tallow kept heated to a temperature of 180° C by a gas stove.

The calorimeter was copper and held 1.35 Kilos of water. To prevent any loss of heat from the water by radiation or rise in temperature by absorbtion of heat from the air, the calorimeter was provided with two jackets

made of wool felt half an inch thick which were used alternately.

The oil bath had a copper cover on which the material to be tested was placed and on this was set the jacketed calorimeter. Thus arranged all the heat which effected the temperature of the water, necessarily passed through the material under trial.

At the beginning of each experiment the calorimeter was filled with fresh water at a temperature of about 21°C and to give time for the regime to become established the experiment was not commenced until the water had reached a temperature of 25° C.

For experiments 1 to 13 the time was observed which was necessary to raise the water each 5° between 25° and 40°. For experiments 13 to 31 the time required to raise the water each degree through 5° was observed and the time for 15° computed.

Sixty four experiments were made but because of variations in the temperature of the oil bath during some of the experiments part of the data are omitted from the following table.

In experiments 15 to 21 a paste board rim of the required thickness was used on which to rest the calorimeter and, with the exception of experiment 16 mineral wool was packed closely around it to make the air as stagnant as possible.

Experiment 16 was tried unpacked because it probably represents more nearly the true condition of the air spaces in the walls of a house.

Table I.

		No. of min. required to raise the water 25°-30°	30°-35°	35°-40°	25°-40°	Average.
1	Parchment Paper	4.5"	4.75"	4.75"	14	13.5"
1	" "	4.	4.5"	4.5"	13	
2	1 Ply P+B. Sheathing	4.5	4.5"	5".	14	14.25"
2	" " " " "	4.5"	5".	5"	14.5"	
3	2 " " " "	5".	5"	5.5"	15.5"	15.5"
4	3 " " " "	5".	5.5"	6	16.5"	16.5"
4	" " " " "	5.5	5".	6	16.5"	
5	Tar Board Paper	6	6.5"	6.5"	19.	19.25"
5	" " "	6.5"	6.5"	6.5"	19.5"	
6	" " "	6.	6.5"	7.	19.5"	19.75"
6	" " "	6.	7.	7	20.	
7	" " "	7.	7	7.5"	21.5"	20.75"
7	" " "	6.5"	6.5"	7.	20.	
8	Asbestos Paper	6.5"	6.5"	7.5"	20.5"	21.
8	" "	7.	7.	7.5"	21.5"	
9	" "	7.5"	7.	7.5"	22.	22.25"
9	" "	7	7.5"	8.	22.5"	
10	" "	7	7.	8.5"	22.5"	22.25"
10	" "	7	7	8	22.	

		25°-30°	30°-35°	35°-40°	25°-40°		
11	Plain Board Paper.	8	7.5	8	23½	23.5	
11	" " "	7.5	8	8	23½		
12	Wool Felt.	8	8	9	25	25-25	
12	" "	8.5	8	9	25½		
13	" "	8½	9.5	10	28	27.75	
13	" "	9	9	9½	27½		
		30°-31°	31°-32°	32°-33°	33°-34°	34°-35°	Computed for 15°
14	Plaster ½" thick.	2.5	3	3.5	3	3.5	46.5
15	Air Space 5/16"	4.	4.5	4.5	4.5	5	67.5
16	" " 5/8" unpacked.	4.5	4.5	4.5	4.5	5	69.
17	" " 5/8"	4.75	5.	5	5	5.25	77 5/8
17	" " "	5	5	5.75	5.5	5.5	
18	" " 2"	6.5	6.5	6.5	6.5	6.5	97.5
19	Mineral Wool 5/16"	7.	7.5	7.	8.	7½	111.
20	Charcoal 5/8"	8	8	8	8½	8	121.5
21	Mineral Wool 5/8"	10	11	10.25	10.25	11	157.5
21	" " "	10	11	10¼	10.25	11	

Table I does not give a correct comparison of the materials because the copper bottom of the calorimeter and the cover of the oil bath offered considerable resistance to the passage of heat.

With no other resistance than the copper the time required to raise the water 15° C was 13 minutes.

In the following table this time is deducted from the results given in Table I. It therefore gives the comparative efficiency of the different materials when only one thickness is used.

1.	Parchment Paper	1/2	8.	Asbestos	8.	15.	5/16" Air Space 54 1/2
2.	1 Ply P+B. Sheathing	1 1/4	9.	"	9 1/4	16.	5/8" " " unpacked 56
3.	2 " " " "	2 1/2	10.	"	9 1/4	17.	5/8" " " 64 5/8
4.	3 " " " "	3 1/2	11.	Plain Paper	10 1/2	18.	2" " " 84 1/2
5.	Tar Paper	6 1/4	12.	Wool Felt	12 1/4	19.	5/16" Mineral Wool 98
6	" "	6 3/4	13.	" "	14 3/4	20.	5/8" Charcoal 108 1/2
7	" "	7 3/4	14.	Plaster	33 1/2	21.	5/8" Mineral Wool 144 1/2

The comparative cost of the different kinds of paper is about as follows.

Table 3.

1.	Parchment Paper	@ 10 cts per lb	=	$.30	per square.
10.	Asbestos	" 11⅕ " " "	=	1.68	" "
11.	Plain Building Paper	" 2½ " " "	=	.26¼	" "
12.	Wool Felt	" 3 " " "	=	.31½	" "
14.	Plaster	@ 30 cts per sq yd	=	3.33	" "
21.	Mineral Wool ⅝" thick, 1¼ cts per lb		=	.77	" "
7.	Tar Board	@ 3 " " "	=	.45	" "

Taking mineral wool as the standard and representing it by 1000 the following table represents the value of the different materials when only one thickness is used. Both efficiency and cost are taken into consideration and the results obtained from the following ratio. The efficiency of Mineral wool : the efficiency of ---- :: The cost of mineral wool : the cost of ---- times (A).

The (A) in each case is given in the table.

Table 4.

Mineral Wool	1000.
Wool Felt	257.
Plain Board Paper	213.
Tar Paper	91.
Plaster	54.
Asbestos	29.
Parchment Paper	9.

The building papers evidently have a very slight efficiency but as they are nearly impervious to air under a normal pressure they can be used most effectively for enclosing air spaces.

Assuming the value of an air space enclosed between two layers of paper to be 56 as in experiment 16 table 2 which is probably an excessive value, for the air in practice could not be made as stagnant as in

the experiment, the relative values of two thicknesses of paper of each of the different kinds with an air space between them is easily determined by adding to 56 in each case twice the value of a single thickness of the paper used. These values are given in the following table for the best paper of each kind.

Table. 5.

Parchment Paper	57.	Asbestos	74½
3 Ply P & B. Sheathing	63.	Plain Paper	77.
Tar Paper	71½.	Wool Felt	85½
		Mineral Wool	144½.

Taking the 5/8" layer of mineral wool as a standard, the next table gives the number of thicknesses of each of the materials which would be required to make a resistance equal to 144½, basing the value of two thicknesses of each of the materials on table 5 and considering that the resistance of the plaster increases directly as its thickness

which throws the error in favor of the plaster for the resistance would not increase in a direct ratio.

Table 6.

Parchment Paper	5.07 layers	Plain Building Paper	3.75 layers
3 Ply P & B. Sheathing	4.59 "	Wool Felt	3.38 "
Tar Building Paper	4.04 "	Plaster ½" thick	4.31 "
Asbestos	3.85 "		

Multiplying these results by the corresponding ones in table 3, gives the cost of the number of thicknesses of each of the different kinds of paper with air spaces between them which will give a resistance equal to a 5/8" layer of mineral wool.

Table 6.

Mineral Wool 5/8" thick	.77 per 100 sq ft.
Plain Building Paper	.98 " " " "
Wool Felt	1.06 " " " "
Parchment Paper	1.52 " " " "
Tar Board Paper	1.82

Mortar @ 20cts per sq yd per in. in thickness $4.78
Asbestos $6.52

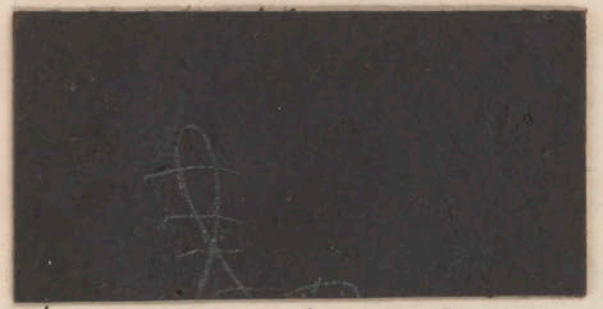
Taking the mineral wool as the standard as before, the following table represents the value of the different papers when used with air spaces between them. Both efficiency and cost are taken into consideration.

Mineral Wool	1000
Plain Building Paper	786
Wool Felt	726.
Parchment Paper	507.
Tar Paper	423.
Mortar	161.
Asbestos	118.

(1) Parchment Paper. 3 lbs per 100 sq ft.

(4) 3 Ply P+B. Sheathing 7 lbs per 100 sq ft.

(2.) 1 Ply P.+B. Sheathing. 3 lbs per 100 sq. ft.



(5) Tar Building Paper 13 lbs per 100 sq ft.

(3) 2 Ply P+B Sheathing 5 lbs per 100 sq ft.

(6) Tar Building Paper 13 lbs per 100 sq ft.

(7) Tar Building Paper 15 lbs per 100 sq ft

(11) Plain Board Paper 10½ lbs per 100 sq ft.

(8) Asbestos Sheathing, 14 lbs per 100 sq ft.

(12) Wool Felt. 11 lbs per 100 sq ft.

(10) Asbestos Sheathing 15 lbs per 100 sq ft.

(13) Wool Felt. 10½ lbs per 100 sq ft.